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PROJECT MONITOR & CONTROL THROUGH MANAGEMENT BY EXCEPTION-A FRAMEWORK FOR SOFTWARE INDUSTRY

Syed Abdur Rahim Md Muinul Islam
MSCSE, United International University, Dhaka, Bangladesh

Dr Hasan Sarwar
MSCSE, United International University, Dhaka, Bangladesh

ABSTRACT

A project is a temporary endeavor undertaken to create a unique product, service, or result based on specific requirements and expectation of customer. The temporary nature of projects indicates that a project has a definite beginning and end. A project is driven by "triple constraints" Scope, Time and Cost which deliver a defined quality product or service in order to succeed, a project must deliver to cost, to quality, and on time; and it must deliver the benefits presented in the business case. The effective implementation of Management by Exception (MBE) for every efficient use of management time as it reduces managers time burden without removing their control by ensuring decision are made at the right level in the organization. The project has defined tolerances for each project objectives to establish limits of a delegated authority. The tolerance is a permissible deviation above and below a plan's target for time and cost without escalating the deviation to the next level of management. The success of the project depends on effective monitoring and controlling of tolerance level of project's parameters to identify the root causes of the issues and properly address these in timely manner.

Key words: Capability Maturity Model Integration, Constructive Cost Model II, Cost Performance Index, Functional Point Analysis, Goal Question Metrics, International Organization of Standards, Key Performance Indicators, Organizational Measurement Repository, Strength Weakness Opportunity Threat.

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1. INTRODUCTION

To achieve the mission critical and time driven business objectives, project management has become a central way for undertaking several of the business activities. The lack of monitoring and controlling tools is one of the increasing and most significant concerns with projects is that, projects are behind schedule, over budget and show unsatisfactory performance in terms quality and customer satisfaction. The “triple constraint”[1] impact the project schedule, cost and scope to deliver the specific product and services as per requirements. In a perfect world every project would be "on time and within budget." But it’s not uncommon for projects to fail. A project is considered a failure when it has not delivered what was required, in line with expectations. Project requires to establish the measurement repository for matrices which present the status of project indicators for evaluation. The main challenges are the identifying the key indicators of the projects and how to extract the data to represent management for decision support. The thesis will work for design a framework to supervise the project with quantitative analysis where tolerances are deviated and evaluate the project through management by exception.

There are a few global standard models are available in the industry such as CMMI,[2] ISO[3], Six Sigma[4] to implement the process to achieve successfully improved quality and productivity, by using the concepts of process management. The thesis explores the relevance of quantitative analysis of project metrics in project management and how the framework can establish the repository with the underlying key indicators by following the tolerance level to support decision making process through management by exception.

The purpose of this thesis is to develop the framework[5] of project monitoring and controlling tools for software industry that basis on underlying quantitative indicators and evaluate management by exception for improving project productivity.

2. LITERATURE REVIEW

To define the metric of the projects, there are some global standards like GQM, SWOT analysis to monitor and evaluate the project. The below techniques are explore to review the metrics process:

2.1. Software Measurement Technique and Review

The measurement process must be integrated into the software lifecycle processes. The phases determine the opportunities for measurement. Because the software process itself, is dynamic-the measurement process also must change and adapt as the program evolves. The major reasoning for measuring software process, products and resources to characterize, evaluate, predict and improve the product quality and process performance. The techniques of deriving measurements and metrics of the software project apply by Goal Question Metrics (GQM), Historical Data from Organizational Repository and SWOT Analysis. The Goal/Question/Metric (GQM)[6] standard affords a framework for deriving measures from measurement goals. The idea is to define a measurement goal with five dimensions as Object of Study, Purpose, Quality Focus, Point of View and Environment. The SWOT[7] Analysis is a very useful tool for decision making and for organizing ones thinking about a certain situation or idea, whether that is a company’s current situation, a certain problem within a company’s process and measures the specific indicator to achieve the goals. The technique focuses on the identification of strong and weak points within an organization and the analysis of opportunities for, and threats to, further development. The Expert Judgment from historical data also derives the measurement indicators for the projects. These are identifying the entity, attribute and measures of the projects to monitor and control.

2.2. Goal Question Metrics

The Goal Question Metric (GQM)[8] approach is based upon the assumption that for an organization to measure in a purposeful way it must first specify the goals for itself and its projects, then it must trace those goals to the data that are intended to define those goals operationally, and finally provide a framework for interpreting the data with respect to the stated goals.

The goal-driven process[9] begins with identifying business goals and breaking them down into manageable sub goals. It ends with a plan for implementing well-defined measures and indicators that support the goals. Along the way, it maintains traceability back to the goals, so that those who collect and process measurement data do not lose sight of the objectives. It clearly defined measures that can be implemented and applied consistently in r organization, in ways that directly support business goals. Table 1 provides the process steps as follows:

Table 1 Process steps

SL	Steps
1	Identify your business goals.
2	Identify what you want to know or learn
3	Identify your sub goals
4	Identify the entities and attributes related to your sub goals.
5	Formalize your measurement goals
6	Identify quantifiable questions and the related indicators that you will use to help you achieve your measurement goals.
7	Identify the data elements that you will collect to construct the indicators that help answer your questions.
8	Define the measures to be used, and make these definitions operational.
9	Identify the actions that you will take to implement the measures
10	Identify the actions that you will take to implement the measures

2.3. SWOT Analysis

SWOT[7] is used as a tool for exploring the constraints and opportunities of a project proposal. It can be used to test the completeness of a goal. Strengths and weaknesses refer to those strengths and weaknesses within the project. Opportunities and threats refer to the opportunities for, and the threats to, the project in respect to achieving the goal. To identify the measures from SOWT, the qualifiers of each SWOT attributes are quantifying with the means of units which can be added in the OMR to monitor and control of the project. The below is the model of SWOT Analysis:

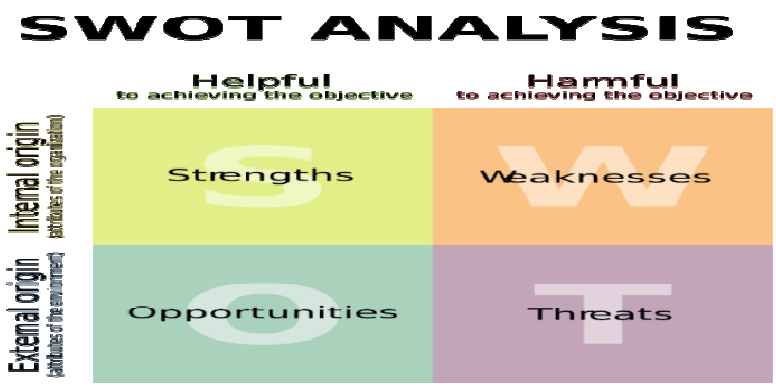

Figure 1 SWOT analysis

The SWOT can be categorized in four elements and define the unit to measure the specific attribute of the component. The below table figure out the process of identifying the measurements of the project as sample basis:

Table 2 Measurements of the project

Element	Strength	Weakness	Opportunity	Threat	Metrics
People	Certified and Professional Employee	Leaving the company is very fast	Brand Value Exclusivity of the products	Exclusivity Regulations Taxation policy	% of Certified & Professional Out turn Rate of employee
Process	Defined SOP	Un updated documents			Nos of artifacts implemented Nos of Non Compliance
Technology	Establish state of the arts technology with tier III data center	Power interruption			NosTechnical Issues Occurred Rate of power failure
Environment	User friendly work environment with multicultural aspects	Flat Management creates conflict of interest			% of environmental issues occurred

2.4. Metrics Uses in Software Projects

The software project's metrics are identified based on the characteristics and criticality of the project features. The common and mostly used metrics are:

Table 3 Software project metrics

Metrics	Definition	Methods & Tools
Size	Software size is widely recognized as an important cost driver for the effort and cost needed for software projects	Functional Point Analysis (FPA)
Effort	Effort estimation is the process of predicting the most realistic amount of effort (Person-Hours/Day/Month or money) required to develop or maintain software based on requirements, risks and constraints.	Constructive Cost Model II (COCOMO II) PM Nominal = A x (SIZE)B Here, PM = Efforts in Person Months A = the constant, used to capture the multiplicative effects on efforts with projects of increasing size SIZE = the unit of software requirements Functional Point (FP) or thousands of source of lines of code (KSLOC) B= accounts for the relative economics or diseconomies of scale of software projects of different size. B= 1.01 + 0.01∑Wi W= summed across all of the factors, and used to determine a scale exponent B
Schedule	It measures the duration of the projects	End Date minus Start Date
Defect Density	Defect Density is the number of defects confirmed in software/module during a specific period of operation or development divided by the size of the software/module. It enables one to decide if a piece of software is ready to be released.	Nos of Defects/Size
Nos of Change Request	Number approved change request (CR) occurs after baseline scope or requirements	Numbers of CR
Project	Budget at completion (BAC) is the original cost	EVM

Metrics	Definition	Methods & Tools
Budget (BAC)	estimate or budget for the project.	
Planned Value (PV)	To figure out what value your plan says you should have delivered so far	PV = BAC x Planned % Complete
Earned Value (EV)	EV lets you translate how much work the team's finished into a dollar value	EV = BAC x Actual %
Actual Cost (AC)	The amount of money you spend doesn't always match the value you get!	
Schedule Variance (SV)	This puts a dollar value on exactly how far ahead or behind schedule you are	EV-PV
Schedule Performance Index (SPI)	The Schedule Performance Index indicates how efficiently you are actually progressing compared to the planned project schedule	EV/PV
Cost Variance (CV)	Your sponsor needs to know how much it costs to get him the value you deliver	EV-AC
Cost Performance Index (CPI)	The Cost Performance Index specifies how much you are earning for each dollar spent on the project. The Cost Performance Index is an indication of how well the project is remaining on budget	EV/AC
Estimate at complete (EAC{t})	The Estimate at Completion (EAC) gives the forecasted value of the project when it is completed. With this data it can forecast how much you may have to spend to complete the project. In other words, it is the amount of money that the project will cost.	(BAC/SPI)/(BAC/months)

3. PROBLEM STATEMENT

3.1. Why projects fail

The reasons for projects failure are many driving factors responsible to lack of analysis of root causes through proper monitoring tools. The main challenges are in the project to identify and capture the information of project's measurement and metrics which assist to management to review the project status whether it's cross the tolerance limit. However, in recent years, there has been an increasing amount of literature consistently showing that Projects often fail. In that they go into frequent cost overruns, delays, and show unsatisfactory performance in terms of quality and customer satisfaction. Cicmil and Hodgson (2006)[10] reported that nearly 30% of product development projects never live up to business objectives. According to Winch (1996) U.K. government procured construction projects ranging from hospitals to roads, suffer from, on average, 14% cost overrun and 11% time overrun. The three common problems described above, were already recorded by the Project Management Institute (PMI) in 1969. Still today, The followings are common causes for project failure by KPMG[11] but not limited to :

- No Business Case
- Vision and goals not well defined
- Insufficient definition of required outcome
- Insufficient communication between stakeholders

- Poor definition of project roles and responsibilities
- Poor estimation of duration and cost
- Inadequate planning and co-ordination of resources
- Insufficient measurable and lack of control
- Changing direction mid-project
- Customer and end users not engaged during project
- Poor leadership
- No buy-in and support from key stakeholders

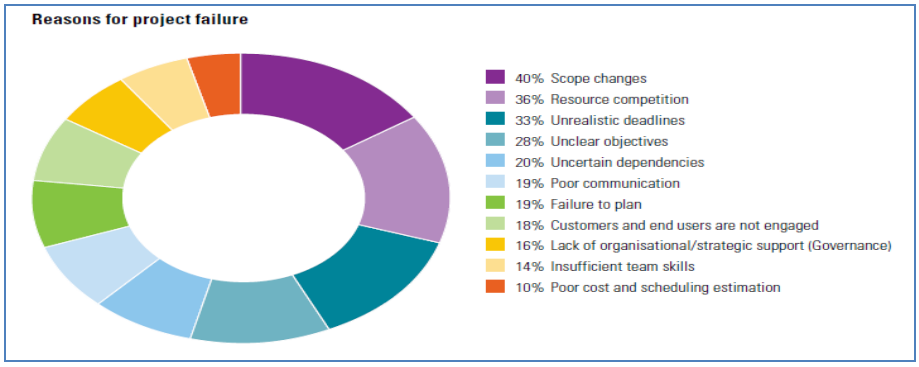

Figure 2 Pie chart depicts the percentage of each reason of project failure

4. CASE STUDY

4.1. Background

The study of the several software projects data metrics have been shown that the project monitoring and control is one of the main area where the project stakeholders unable to oversee the key performance indicators (KPI) of the projects and its phases. The inadequate data is the key factors to reflect the actual status of the project. The KPIs are not well defined while project had been kicked off. The extraction of data sources are not aligned with the measurement repository which is not reflected the project status at a glance for higher level management. As the study is based on the software projects to define the measurement and metrics to monitor and control, the project data has been collected from software industry derived from various phases of life cycle of the projects obtained from organizational process assets and measurement and metrics. The company Lead Soft Bangladesh is the largest software house and studies the projects of the company to evaluate the software metrics and project monitoring & control processes. The CMMI has defined the four categories Process, Project Management, Engineering and Supports including 22 process areas within the categories. The projects are implemented through various types of artifacts like template, form, guideline, checklists etc. The data shown the 117 artifacts implemented in 8 projects and function which explore the status as below:

4.2. Selection across projects

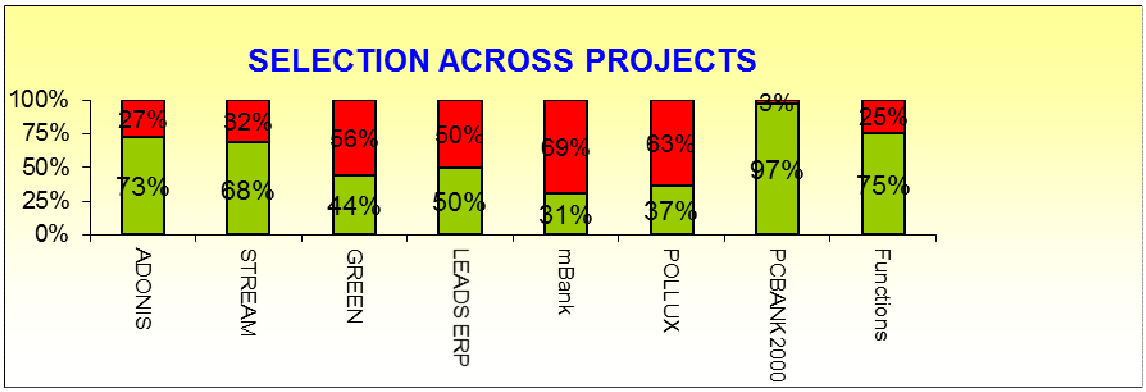

Figure 3 Selection across projects

4.3. Implementation status across projects

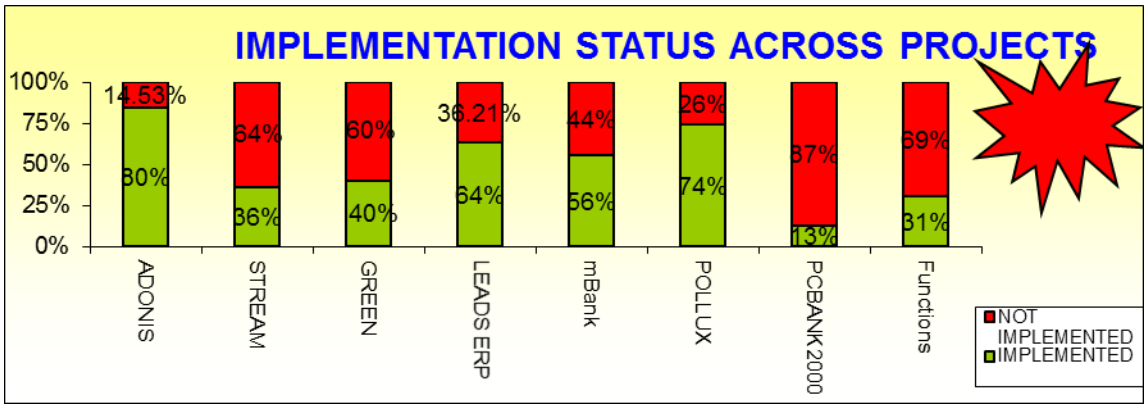

Figure 4 Implementation status across projects

The above data reflects the implementation of process assets which are not obtained in the project life cycle and the red areas are the vulnerable for the project. The drawback for the projects to identify the KPIs from project characteristics and organizational repository. The basic measurements for the software projects are the Size, Effort Variance, Schedule Variance, Defect Density etc. It has found that other KPIs for the project are not identified and measure as there is no model or approach to identify the metrics which are vital to monitor the project. The Earned Value Management (EVM)[12], Goal Question Metrics (GQM)[8], SWOT Analysis tools are very effective to analyze the projects aspects and measurement to define the monitoring framework and establish the repository for oversee the project status.

5. METHODOLOGY

5.1. Research Method

In respect to research, the attributes which are deemed to be identified the quantitative analysis of project metric based on literature review and the other techniques of the metric and measurements. In seeking an answer to the research question, we have reviewed discussions on the objectivity and complexity of the applicability of the measurements/metrics. The literature we have surveyed caused us to think on whether the metrics are identify using any

tools or what types of measurement are captured in their project. In the case, we set the goal and accordingly aim to define the research methods below:

Figure 5 Research method

5.2. Data Collection & Analysis

The below template data collected from various project and persisted in the OMR application to automate and produce the metrics.

Table 4 Data collection template

Description of Project	Author	Date

1. What are the sources of project measurements?
    a. Organizational Process Assets
    b. Expert Judgment
    c. Using Tools and Techniques
    d. Default
2. What are the measurements and metrics for the project?

Table 5 Measurement & metrics

Measurement & Metrics	Definition
Size (FP)	
Schedule	
Efforts	
Defect Density	
CPI	
SPI	

2. How do preserve and analysis the measurement?
    a. Spread Sheet
    b. Organizational Measurement Repository (OMR)
    c. Not Available
3. What are the plans, actual and variances of measurement and metrics?

Table 6 Plan, actual and variances of measurement and metrics

Metrics	Plan	Actual	Variance

4. How frequent project monitoring and controls conduct by Senior Management?
    d. 10% of Project Lifetime
    e. 20% of Project Lifetime
    f. 30% of Project Lifetime
    g. 40% of Project Lifetime

Table 7 Sample project data set

Project	Metrics	Value	Unit
Cupon	Actual % Completed	70	Percentage
Cupon	Cost	80000000	Currency
Cupon	Cost Performance Index	1.15	Basis
Cupon	Defect Density	0.3	Basis
Cupon	Effort	12	Person Month
Cupon	Onsite Support	150	Hour
Cupon	Planned % Completed	80	Percentage
Cupon	Schedule	250	Days
Cupon	Schedule Performance Index	1.15	Basis
Cupon	Size	2000	Functional Point
Prism	Actual % Completed	90	Percentage
Prism	Change Request	15	Nos
Prism	Cost	201000000	Currency
Prism	Cost Performance Index	0.9	Basis
Prism	Defect Density	0.3	Basis
Prism	Effort	14	Person Month
Prism	Planned % Completed	85	Percentage
Prism	Schedule Performance Index	0.95	Basis
Prism	Size	2000	Functional Point
CAnalytis	Actual % Completed	95	Percentage
CAnalytis	Cost	16000000	Currency
CAnalytis	Cost Performance Index	1.2	Basis
CAnalytis	Effort	100	Person Month
CAnalytis	Planed Value	100000000	Currency
CAnalytis	Planned % Completed	100	Percentage
CAnalytis	Size	2500	Complexity Unit
CAnalytis	Size	2500	Complexity Unit

5.3. Establish Organizational Measurement Repository (OMR)

There are several models for identifying metrics for the project, but the complexity of the measure is to align with its project aspects and easiness of monitoring & controlling. In traditional way of quantifying the projects metrics are showing the trivial and very tough to fit with OMR. The study is based on GQM, SWOT and Expert Judgment (historical data) tools to define the project metric which will be mapped with OMR through application. The framework work basics are developed with tolerance level to monitor and control the projects.

The below process extract the metrics from various techniques and develop the organizational measurement repository (OMR).

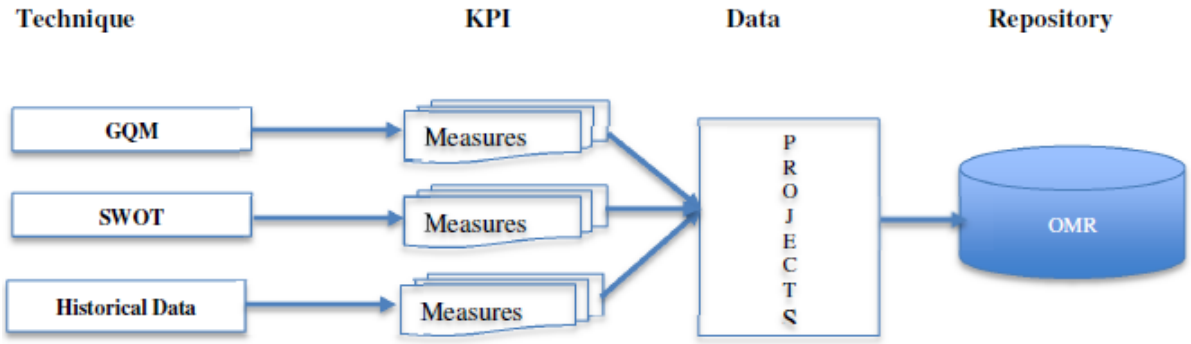

Figure 6 Organizational measurement repository

6. RESULT

As summarized project data analysis, literature reviews, various type of metrics definition and clustered above, the framework basics of measurement is defined how project data will persist in the repository and set the tolerance level of measures. The PMC application is developed to capture the data to get the status of the projects. The output of the PMC from OMR database, the stakeholders can view the project performance which assists to effective decision making process. The PMC also provide the output result of the project based on defined metrics in graphical representation. The Application is very simple to maintain project data to monitor and control the project performance in the software industry.

6.1. Framework Basics

The progress[13] is the measure of the achievement of the objective of a project plan. The projects controls are required to monitor the project progress in different stages of life cycle. By analyzing project characteristics using techniques like GQM, SOWT, Expert Judgment, the projects measures can be identified and according to set the indicators and tolerance level of different stages of project. The below table shows the structure of sample tolerance level of different stages based on extracted or derived data from projects:

Table 8 Structure of sample tolerance level of different stages

Tolerances	Project Level		Stag1/Iteration1		Stage(n)/Iteration(n)	
	Max	Min	Max	Min	Max	Min
Time	99~105					
Cost	99~105					
CPI	.99~1.05					
SPI	.99~1.05					
Defect Density	0.25~0.35					
Scope	Qualitative					
Risk	30~40					
Quality	Qualitative					
Benefit	Qualitative					

Though the reasons are diversified in many ways, the main objective is to provide a framework to preserve the information for proper monitoring and control. The process framework[5] will preserve the data to representation of the status from repository:

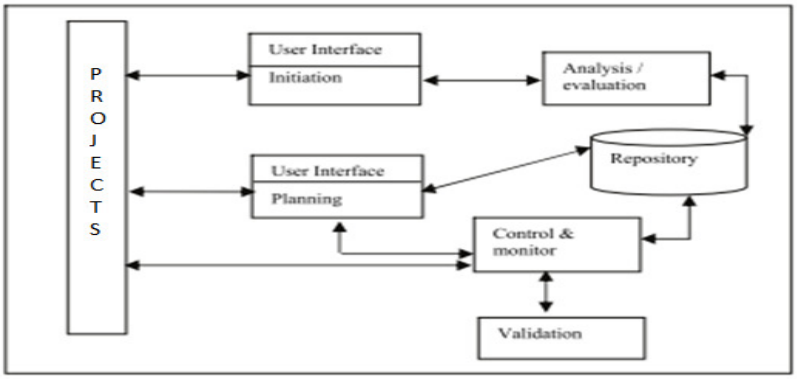

Figure 7 Framework to preserve the information for proper monitoring and control

6.2. Analytics

The prime concern of monitoring and control is to identify the common cause of effects and special cause of effects. If the tolerance[13] level exceeded in any parameter, the special cause should be analyzed and within the tolerance level the optimization is taken care of the process and products. The qualitative risk[14] analysis are also taken care of the repository. The project will control through Management by Exception[13].

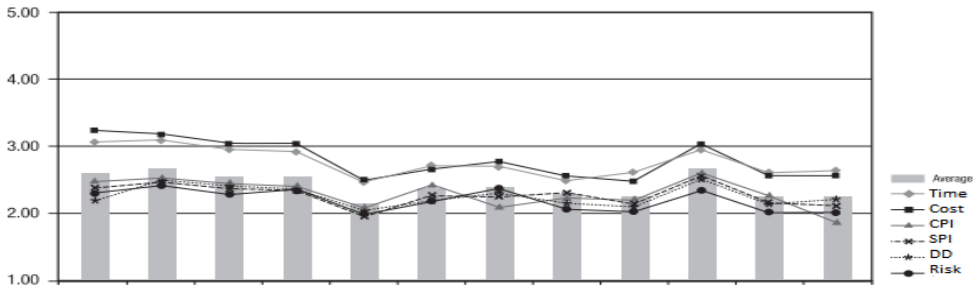

Figure 8 Tolerance level between 2.00-3.00

The above graph has shown the tolerance level between 2.00-3.00 by which management can monitor and control the project status for decision making.

6.3. OMR Application –PMC

The Organizational Measurement Repository (OMR) is developed to preserve the metrics data for processing and analyzing to monitor & control of various project's aspects. The OMR Application is named as PMC (Project Monitoring & Controlling) .The application tools PMC is developed to maintain the project data for OMR. The project data extract from defined project information to evaluate the project status and OMR persists the data and process through application and provide the output to visualize the project health. The PMC is developed on n-tier architecture with ASP.NET and using the database MSSQL Server as backend.

6.4. LIMITATION OF THE STUDY

The study is based on software industry and selected 15 projects from specific large industry in Bangladesh which is rated as CMMI Level 5 Company. The project data are captured from specific project metrics available at the time which can impact the measurement data. The research methodology is tailored to support application development process in iterative mode. As there are lot of metrics extraction tools, but the study only sleeted the GQM, SWOT and expert judgment to simplify the identification of measures. OMR is only to persist the project data and issue management function is related with project. Presently the OMR is generated for Software Industry perspectives.

7. CONCLUSION

Establishing an OMR is the vital backbone of an organization to persist and maintain all the measurement data of the projects. The historical information can provide the organization to visualize the future projects risk and constraints and to forecast the planning with effectiveness. The study developed a framework of IT project management trough quantities analysis by setting the tolerance level and monitor & control the projects management by exception within the metric's limits. The OMR may generate a method of approach to introduce the application of metrics and measurement within software industry with simple approach. When establishing such a method, the limitations of the results presented in Section 6.4 should be considered. A general limitation is that the interview is conducted locally. However, this limitation is not a great constraint as the OMR application is parameterize and can be tailored for any organization suits.

In future the API (application program interface) will be developed to integrate the PMC application with any 3rd parties OMR to process the data to monitor & control the projects through web and apps based tools.

The metrics will be open mode to cover all the industries to adopt their measurement & metrics.

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